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Government management capacities and the containment of COVID-19: A repeated cross-sectional study across Chinese cities

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ABSTRACT

Objectives Better understanding of the dynamics of the COVID-19 (2019 novel coronavirus disease) pandemic to curb its spread is now a global imperative. While travel restrictions and control measures have been shown to limit the spread of the disease, the effectiveness of the enforcement of those measures should depend on the strength of the government. Whether, and how, the government plays a role in fighting the disease, however, has not been investigated. Here, we show that government management capacities are critical to the containment of the disease.

Setting We conducted a statistical analysis based on cross-city comparisons within China. China has undergone almost the entire cycle of the anticoronavirus campaign, which allows us to trace the full dynamics of the outbreak, with homogeneity in standards for statistics recording.

Primary and secondary outcome measures Outcome measures include city-specific COVID-19 case incidence and recoveries in China.

Results The containment of COVID-19 depends on the effectiveness of the enforcement of control measures, which in turn depends on the local government's management capacities. Specifically, government efficiency, capacity for law enforcement, and the transparency of laws and policies significantly reduce COVID-19 prevalence and increase the likelihood of recoveries. The organisation size of the government, which is not closely related to its capacity for management, has a limited role.

Strengths and limitations of this study

- ► We are among the first to examine the role of government management capacities in the containment of COVID-19.
- ► We conducted a repeated cross-sectional study in China which ensures consistency in standards for statistics recording and homogeneity in institutional features.
- ► We were able to trace the full dynamics of the outbreak in the setting of Chinese cities.
- ► The specific measures of government management capacities may not be readily comparable with cities in other countries.
- ► The restrictive government disease control practices may also not be readily applicable to other countries.

INTRODUCTION

COVID-19 outbreaks have raced around the world and have exploded into a pandemic. About 47.3 million infections have been confirmed in more than 200 countries and territories. It has become a global imperative to better understand the dynamics of this pandemic in order to limit its ongoing spread.

China, which was the first country exposed to the coronavirus, has almost completed the full cycle of the anticoronavirus campaign. Since mid-March 2020, daily new cases in China have been reduced to near-zero levels (figure 1). This result is substantially attributed to the strict travel restrictions and containment measures, such as suspending public transport, closing entertainment venues and banning public gatherings, implemented by Chinese authorities.[1–5] The WHO has repeatedly praised China for its effective response to the COVID-19 outbreak.

Yet China's response is not free of controversy, in particular whether the government and the measures it has taken have succeeded in fighting the disease. For instance, sceptics point out that other places, such as Singapore, imposed similar containment measures but still experienced an enormous outbreak.[6 7]

The effectiveness of the enforcement of control measures should depend on the strength of the government, as indicated by the notion of state capacity. State capacity is shown to be crucial to economic development and technological change.[8 9] The rapid economic growth in East Asian economies, in particular, can largely be accounted for by states with a great deal of capacity.[8] During this pandemic, heated discussions have centred on responses by different countries,

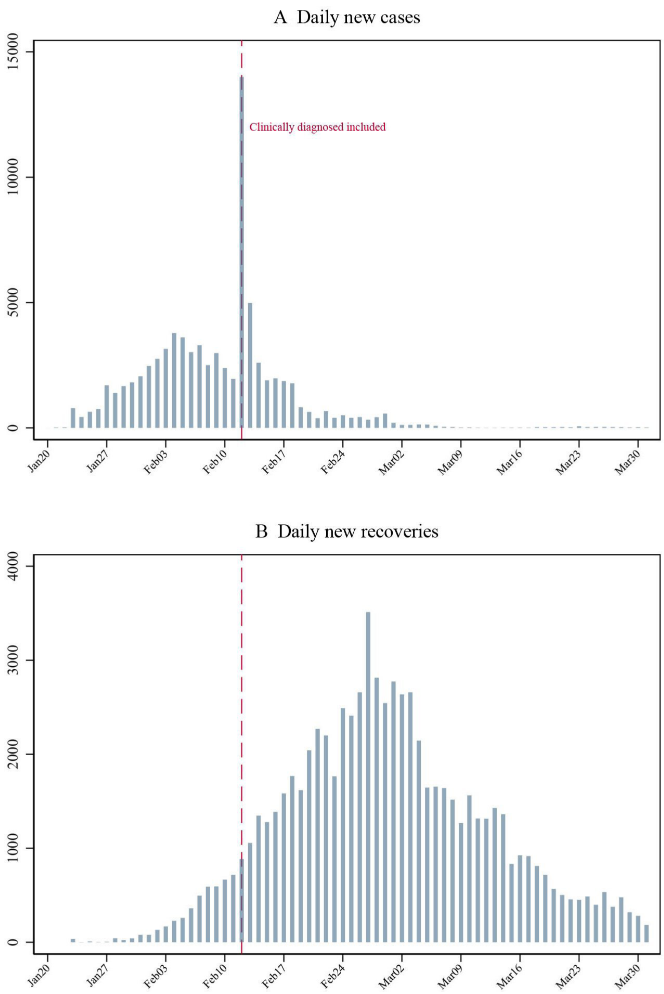

Figure 1 Daily (A) new cases and (B) recoveries in China, January–March. From 12 February on, new cases include clinically diagnosed cases, in addition to those confirmed by nucleic acid tests, for cities in Hubei Province. This results in a sharp increase in the number of daily new cases, as indicated by the vertical line in the first plot.

which are said to 'reveal the need for a strong state'.[10] The discussions echo the notion of state capacity or government management capacity. Anecdotal evidence indicates that within China there are fewer COVID-19 cases in cities that implemented control measures more pre-emptively,[1] which highlights the importance of the management capacity of local governments for containing the disease.

Whether, and how, the government plays a role in fighting the disease, however, has not been formally investigated. In this paper, we show that government management capacities are critical to the containment of the disease by conducting a statistical analysis based on cross-city comparisons within China. Because China has undergone almost the entire cycle of the anticoronavirus campaign, we can trace the full dynamics of the outbreak while being consistent in standards for statistics recording. We find that better government management—as measured by government efficiency, capacity for law enforcement, transparency of laws and policies, and an aggregate management index—is significantly associated with both reductions in case incidence and increases in recoveries. Government organisation size, in comparison, has an insignificant effect.

These findings demonstrate the important role of the government in controlling COVID-19 and thereby help political leaders and health authorities around the world better understand the dynamics of the pandemic. They also contribute to discussions of the need for strong states as revealed by the pandemic.[10]

Government management capacity

In epidemiology, compartmental models suggest that the implementation of effective public health measures lowers the infection rate and reduces the case incidence.[11 12] The implementation of public health measures, in turn, is related to the notion of state capacity—or, more specifically, government management capacity—in economics.[8 9] To examine the role of state capacity in the containment of COVID-19 in China, we draw a spectrum of measures from the 2019 Global Urban Competitiveness Yearbook:

- Government efficiency measures administrative procedures and time lags in the local government's functions.
- Capacity for law enforcement measures the local government's ability to enforce the rule of law.
- Transparency of laws and policies measures how well laws and policies stipulated by the local government are known to citizens.
- Government organisation size refers to the number of employees in government agencies and organisations as a percentage of total population.
- An aggregate government management index measures the overall management level and public policy environment of a city.

The four subindicators and the aggregate index are closely related to the management capacity of local governments. All of them are on a 10–100 scale. A large value indicates better management of the local government (see online supplemental file 1 for details about the construction of these measures).

Study design

Our study design is based on three unique contextual features. First, as noted earlier, China is in the final stage of the COVID-19 outbreak, which allows us to trace the full dynamics of the outbreak. Second, a within-country analysis ensures homogeneity in the national response, institutional background, and more importantly standards for COVID-19 statistics recording. Third, China banned travel to and from Wuhan City—the epicentre of the outbreak—on 23 January 2020. The ban impeded the growth and limited the size of the epidemic elsewhere in the country, and as a result allowed local governments to undertake effective control measures.[5]

Specifically, we conducted a statistical analysis in which we exploit variations in a spectrum of city-specific government management capability measures and examine how those variations are linked to variations in the effectiveness of COVID-19 control. According to the Ministry of Civil Affairs, there are 333 prefecture-level cities in China, which include prefectures, municipalities, provincial county-level cities and subprovincial cities (special administrative regions, Hong Kong and Macau, and Taiwan are excluded). We included 332 in our sample and excluded the epicentre, Wuhan City. The sample spans a period of 3 months, from January to late March. This period immediately followed the Wuhan lockdown, when local governments began to implement various measures to curb the further spread of infections.[1] We use ordinary least squares regressions to examine the effects of government management in different phases of the outbreak, on a weekly basis. We carried out the statistical analysis using Stata V.16.

In the regression models, outcome variables are the number of new cases and the number of new recoveries in a city. Those numbers have been recorded daily by the National Health Commission of China since January 2020, which we aggregate into weekly data. Recovery rate, defined as the cumulative total recoveries over the cumulative number of closed cases (recoveries plus deaths), has been more than 95%.

Explanatory variables include a set of city-specific, time-invariant determinants of the spread and control of COVID-19. We are particularly interested in the above-mentioned government management capability measures. We also examine other important determinants: population age structure, connection with Wuhan and the local health system's capacity. Data on population age structure (elderly, children and working-age population as a percentage of total population) are from the 2015 China population mini-census. Based on an index of the size of daily population flow that proxies for the total intensity of migration out of Wuhan to other cities (provided by Baidu Migration), we constructed a variable by calculating the average of the migration index over 14 days before the lockdown of Wuhan. We also considered the share of Wuhan-origin residents in the city, using data from the census. Health system capacity is proxied by the total number of hospital beds in the city and the total number of hospital employees, based on data from the 2019 China City Statistical Yearbook (see Extended data table 1 in online supplemental file 1 for definitions and summary statistics of these variables).

Patient and public involvement

No patients were involved in this research.

RESULTS

Figure 2 displays the estimated coefficients on the key determinants from regressions of the number of new cases (in panel A) and new recoveries (in panel B) in a week at the city level. The orange vertical bars are the 90% CIs. For example, the first bar in each plot of panel

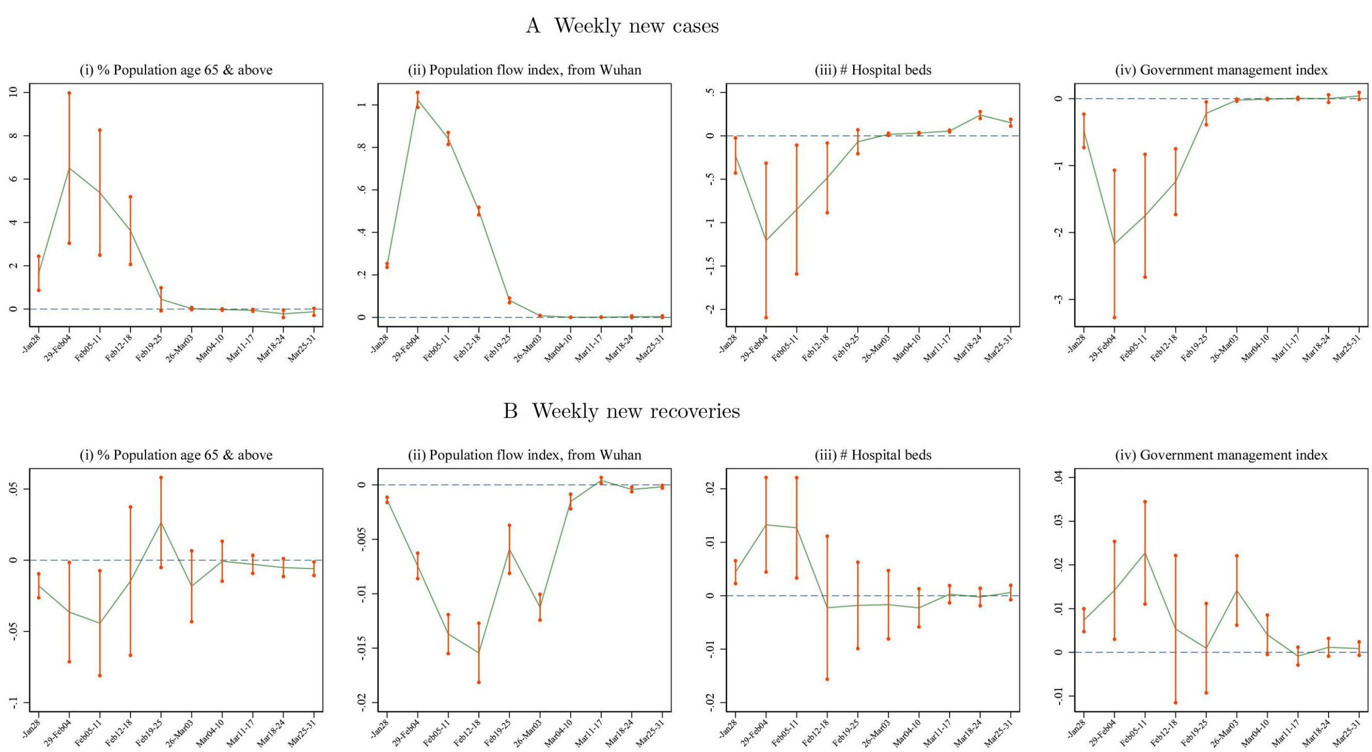

Figure 2 Coronavirus cases and recoveries: key determinants. Each panel displays the estimated coefficients from the regressions of weekly number of (A) new cases and (B) recoveries within a city on four key determinants; 90% CIs are shown as orange vertical bars. All regressions control for percentage of population aged 65 and above, share of Wuhan-origin residents (or an index of population flow from Wuhan), total population, employment rate, percentage of population with a college degree and an indicator variable for municipality. In panel B, regressions additionally control for the number of closed cases.

A regresses the number of cases for the week ending 28 January on city-level factors. The second bar regresses the number of cases for the week ending 4 February on the same city-level factors, and so on. Additional control variables include the share of Wuhan-origin residents, total population, employment rate, percentage of population with a college degree and an indicator variable for municipality. For recoveries, regressions also control for the number of closed cases in that week. Conditional on those variables, the estimated coefficients from the regressions reflect the effects of the determining factors of our interest during the coronavirus outbreak.

Population age structure

As the first column of figure 2 shows, the proportion of people aged 65 and above is closely related to the morbidity and mortality of COVID-19, especially in the initial phase of the outbreak. Specifically, a larger share of the elderly in the local population is associated with more confirmed cases and fewer recoveries. This is in line with our expectation that the elderly have higher COVID-19 infection and death rates, and more elderly predict a larger chance of infection among high-risk populations. In panel A, the small negative effects at the tail of the curve are in line with the interpretation that the elderly realise that they are particularly vulnerable and therefore pay closer attention to protecting themselves from the virus (see tables S1-1 to S1-10 in online supplemental file 2 for regression results). We also verify that normalising the aggregate variables, such as the number of new cases, the number of new recoveries and the number of hospital beds, by city-level population size yields similar patterns of results, as shown in Extended data figure 1 in online supplemental file 1.

In comparison, the share of children (age 0–15) does not have a clear relationship with the spread of the virus; the share of the working-age population (age 16–55) is negatively associated with the number of new cases and positively associated with the number of recoveries, as expected (see Extended data figure 2 in online supplemental file 1 and tables S2-1 to S2-10 in online supplemental file 2).

Connection with the epicentre

The second column of figure 2 indicates that a connection with Wuhan is a crucial determining factor. A larger index of population flow from Wuhan to a destination city is associated with more infected cases and fewer recoveries. This finding corresponds with the interpretation that population flow out of the epicentre of the outbreak increases the likelihood that people who are infected will come into contact with people who are not. We observe that the effects on new cases vanish at the end of February, while the effects on recoveries appear strong across different stages of the outbreak and last to mid-March.

Health system capacity

The third column of figure 2 shows that during the early phases of the outbreak, health system capacity—as proxied by the total number of hospital beds—is negatively associated with the number of new cases and positively associated with the number of recoveries. A local health system's capacity to effectively admit those who are already infected is crucial to reducing transmission among residents, and the capacity to respond to the needs of the infected, who often require admission to an intensive care unit, is vital to increasing the chance of recovery.

During the later phases of the outbreak, however, the effects of health system capacity become insignificant. At the end of March, the effects on new cases turn positive, which is partly due to China's patient reallocation strategy: the central government transferred some patients from cities where local health systems were overwhelmed to nearby cities with greater availability of medical resources.[13] However, this move may result in more coronavirus transmission in destination cities. (Using the number of hospital employees as a proxy for health system capacity yields similar conclusions; see Extended data figure 2 in online supplemental file 1 and tables S2-1 to S2-10 in online supplemental file 2.)

Government management index

The last column of figure 2 shows that the government management index is an important determining factor of the spread and control of COVID-19. Better government management is significantly associated with reductions in case incidence, with the largest effect observed from early through mid-February, when the outbreak was at its peak. This pattern is similar to the effects of local health system capacity shown in the third column of panel A. The small positive effect at the end of March can also be attributed to the patient reallocation strategy, whereby patients tend to be transferred to cities with better government management.

In addition, better government management is associated with increases in the weekly number of recoveries conditional on the number of closed cases, as panel B shows. The effects appear to be the largest in mid-February and are stronger and longer lasting than the effects of health system capacity. We further divide the cities into subgroups based on four criteria and conduct a series of subgroup analyses. We discuss the results in online supplemental file 1 under the 'Subgroup analysis' section (see Extended data figures 3–6 in online supplemental file 1 for results).

While governments with better functions, such as higher government efficiency and transparency of laws, can implement better disease control measures and thereby reduce new cases and increase recovery cases, other pathways of the effects may exist. For instance, it is possible that governments with higher transparency are more accurate in releasing case numbers, which might lead to a larger number of new cases and a smaller number of recovery cases. This possibility, however, does not substantially affect the interpretation of our results. The other pathway of the effects implies that the values of the outcome variables contain non-random measurement

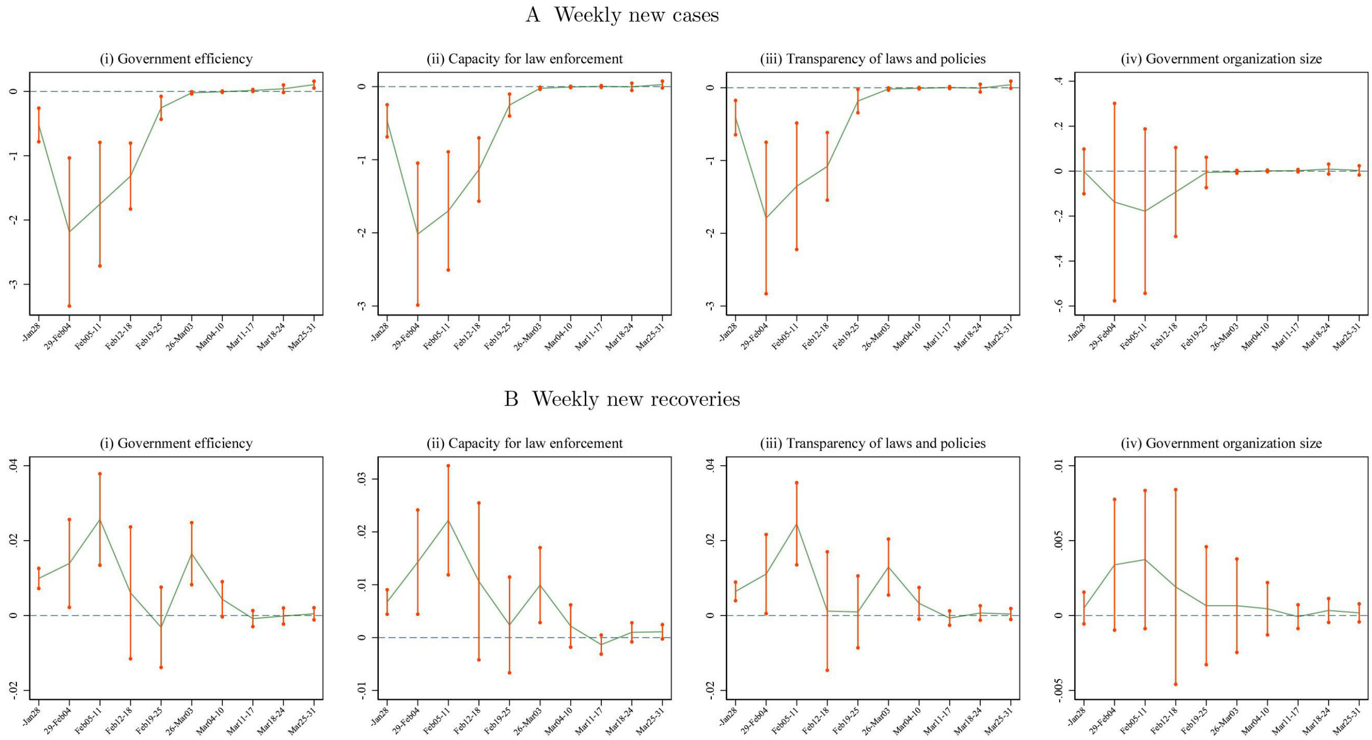

Figure 3 Coronavirus cases and recoveries: the role of government management. Each panel displays the estimated coefficients from the regressions of weekly number of (A) new cases and (B) recoveries within a city on four indicators of government management capabilities; 90% CIs are shown as orange vertical bars. All regressions control for percentage of population aged 65 and above, share of Wuhan-origin residents, total population, employment rate, percentage of population with a college degree and an indicator variable for municipality. In panel B, regressions additionally control for the number of closed cases.

errors, which would give rise to a downward bias in the estimations. Therefore, the effect we have identified in the statistical analysis at least represents a lower bound of the true effect of government management capacities on the disease control, which applies to both new and recovery cases.

To gain a more comprehensive understanding of the government's role in curbing the coronavirus outbreak, we further regress the number of new cases and recoveries on a weekly basis on the four subindicators of government management capabilities separately, plus a range of control variables.

Figure 3 displays the estimated coefficients on the subindicators and the CIs. We find that government efficiency, capacity for law enforcement, and transparency of laws and policies exhibit similar patterns of effects as the aggregate index; they are negatively related to the number of new cases and positively related to the number of new recoveries. The effects of government organisation size, in comparison, are insignificant in both new infections and new recoveries (see tables S3-1 to S3-10 in online supplemental file 2 for regression results).

For regressions of new cases, the R-squared ranges from 0.1 to 0.6, showing a reasonably good goodness of fit. For regressions of new recoveries, the R-squared is high because we control for the number of closed cases (recoveries plus deaths) in the week. Especially towards the end of the period, there were fewer deaths and the number of recoveries was very close to the number of closed cases, which lead to high R-squared.

DISCUSSION

The patterns documented demonstrate that, in addition to demographic controls, the containment of COVID-19 critically depends on the effectiveness of the enforcement of control measures designed for this purpose, which in turn depends on the local government's management capacities. Specifically, government efficiency determines the local government's competence in implementing containment measures; capacity for law enforcement determines how well the government can strengthen and effectively enforce containment measures; and the transparency of laws and policies determines how interim measures are understood, supported and cooperated with by citizens. Therefore, they significantly reduce COVID-19 prevalence and increase the likelihood of recoveries. The organisation size of the government, which is not closely related to its capacity for management, has a limited role.

In addition, our results show that new recovery rates, which have a positive association with health system capabilities, also have a positive association with government management capacities. This is possibly because health system capabilities heavily depend on government functions, especially in China, where a large share of health-care sectors are managed—and at least partly owned—by the government. Therefore, government management capacity would have an impact on the efficiency and effectiveness of healthcare and medical resource allocations, which in turn determine the treatment outcomes for infected patients. Indeed, we have seen from figure 2 that the graphical patterns of the effects of the proxy for health system capacity (the number of hospital beds) and the proxy for government management capability (the government management index) appear similar.

We now discuss the potential methodological limitations of our study. First, our study is based on observational data instead of experimental data. Unobservable heterogeneity across cities in, for example, hygiene and nutrition, is likely to be correlated with the capacity of the local government and at the same time has an impact on the containment of the disease. As a result, it is difficult to directly obtain rigorous causal inference from the regression analysis. Second, our findings are based on a repeated cross-sectional study across Chinese cities, which may lack external validity due to the potential differences across countries in terms of institutions and legal systems. Third, although we have provided some plausible explanations, we cannot identify the exact mechanisms through which government effectiveness plays a role in the containment of the disease—for instance, whether public health measures or restrictions of mobility are more critical. Last, while our study has shown that governments with higher management capacities could impose effective containment measures to reduce COVID-19 prevalence, it keeps silent on whether the measures are cost-effective. A further cost–benefit analysis might be needed to provide better policy suggestions.

CONCLUSION

We have discussed, and formally investigated, the role of government in the containment of COVID-19, based on cross-city comparisons within China. We show that government management capacities are vital to controlling the disease.

Our analysis neither speaks to the feasibility of specific containment measures—whether they can be replicated outside China—nor to the suitability—whether they are violations of human rights.[14] With that caveat, our analysis shows that government management capacities are strongly associated with the containment of COVID-19. This study could help political leaders and health authorities around the world better understand the government's role in controlling the outbreak. In particular, governments that are slow and inefficient in response to the outbreak may contribute to its continuing spread worldwide.[10] This could have important implications for future epidemics and public health emergencies.

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Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

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REFERENCES

1 Tian H, Liu Y, Li Y, *et al*. An investigation of transmission control measures during the first 50 days of the COVID-19 epidemic in China. *Science* 2020;368:abb6105
2 Kraemer MUG, Yang C-H, Gutierrez B, *et al*. The effect of human mobility and control measures on the COVID-19 epidemic in China. *Science* 2020;368:abb4218
3 Maier BF, Brockmann D. Effective containment explains subexponential growth in recent confirmed COVID-19 cases in China. *Science* 2020;368:abb4557
4 Chinazzi M, Davis JT, Ajelli M, *et al*. The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science* 2020;368:aba9757
5 Fang H, Wang L, Yang Y. Human mobility restrictions and the spread of the novel coronavirus (2019-nCoV) in China. *NBER Working Paper* 2020:w26906.
6 The Economist. Not even Singapore has been able to avoid a lockdown. *Economist* 2020.
7 Carroll A. Lesson from Singapore: why we may need to think bigger. *New York Times* 2020.
8 Acemoglu D, García-Jimeno C, Robinson JA. State capacity and economic development: a network approach. *Am Economic Rev* 2015;105:2364–409.
9 Acemoglu D, Moscona J, Robinson JA. And American technology: evidence from the nineteenth century. *AER* 2016;106:p20161071.
10 Fukuyama F. Nous allons revenir un libéralisme des années 1950-1960. *Le Point* 2020.
11 Kermack WO, McKendrick AG. A contribution to the mathematical theory of epidemics. Proceedings of the Royal Society of London. series a, containing papers of a mathematical and physical character 1927;115.
12 Ferguson N, Laydon D, Nedjati Gilani G, *et al*. Report 9: impact of non-pharmaceutical interventions (NPIs) to reduce COVID19 mortality and healthcare demand 2020;77482.
13 Dispersing COVID-19 patients in Wuhan to other cities for better treatment. Available: http://liuyan.people.com.cn/threads/content?tid=6933339
14 Eve F. China's reaction to the coronavirus outbreak violates human rights. *The Guardian* 2020.

Supplementary File 1

This document contains description of the Empirical Methods, Subgroup Analysis, and Extended Data Figures 1-6 and Extended Data Table 1.

Methods

Estimation sample

Our estimation sample contains 332 prefecture-level cities in China and spans a period of 3 months, from January to late March. This period contains ten weeks in total, immediately following the Wuhan lockdown.

Regression specifications

Our empirical analysis exploits variations in city-specific government management capability measures and examines how they are linked to variations in the effectiveness of COVID-19 control. Specifically, we estimate the following regression model on a weekly basis:

$$y_{it} = \beta_0 + \beta_1 Gov_i + X_i\Gamma + \varepsilon_{it},$$

where outcome variables y_{it} are the number of new cases and the number of new recoveries in city i for week t. These numbers have been recorded daily by the National Health Commission of China since January 2020; we aggregate the data into weekly frequency. Recovery rate is defined as cumulative total recoveries over the cumulative number of closed cases (recoveries plus deaths).

Explanatory variables include a set of city-specific, time-invariant determinants of the spread and control of COVID-19. Those of our particular interest are a variety of government management capacity measures, Gov_i for city i, drawn from the 2019 Global Urban Competitiveness Yearbook. Other important determinants are population age structure, connection with Wuhan, and the local health system's capacity. The construction and data sources of these variables are discussed later in detail.

Additional control variables X_i include the share of Wuhan-origin residents, total population, employment rate, percentage of population with a college degree, and an indicator variable for municipality. For recoveries, regressions also control for the number of closed cases in that week. Conditional on these variables, estimated coefficients from the regressions reflect the effects of the determining factors of our interest during the coronavirus outbreak.

We use ordinary least squares regressions to examine the effects of government management in different phases of the outbreak, on a weekly basis. The statistical analysis is carried out using Stata 16.

Government management capacity measures: data source

We draw data on the government management index and four sub-indicators—government efficiency, capacity in law enforcement, transparency of laws and policies, and government organization size—from the 2019 Global Urban Competitiveness Yearbook. The Yearbook is published by the Chinese and Foreign Institute of City Competitiveness, the Hong Kong Gui Qiang Fang Institute of Global Competitiveness, and the World Organization for City Cooperation and Development.

Researchers from these institutes collect information from various professional yearbooks—such as the China City Statistical Yearbook—and cities' yearbooks or official websites—such as Statistical Bulletins. Based on such information, they construct various indicators of cities' competitiveness—including government management—and carry out expert evaluations to make the indicators as accurate, objective, and comparable as possible.

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Government management capacity measures: construction

All data reported in the Global Urban Competitiveness Yearbook are processed following two steps. The first step is indexation of original indicators. The formula of indexation is as follows,

$$X_i = \frac{x_i - \min(x)}{\max(x) - \min(x)}$$

where X_i is indicator i's value after indexation; x_i is indicator i's initial value; $\max(x)$ and $\min(x)$ are the maximum and minimum of indicator i's initial values in the sample of cities, respectively. When an indicator has an initial value of the minimum in the sample, the value after indexation would be 0. In order not to mistake these indicators as having an initial value of 0, we convert the indexed indicator X_i to one that is evenly distributed between [10, 100], using the following formula,

$$Y_i = 90X_i + 10$$

The second step is standardization of the indexed indicators, based on the following formula,

$$z_i = \frac{Y_i - \bar{Y}}{\sigma(Y)}$$

where z_i is indicator i's value after standardization; Y_i is the indexed indicator that is evenly distributed between [10, 100]; $\bar{Y}$ and $\sigma(Y)$ are the mean and standard deviation of Y_i, respectively. After standardization, each indicator has a mean of 0 and a standard deviation of 1.

In constructing various indicators of the competitiveness of cities, sub-level indicators are first processed following the two steps. Then each aggregate indicator is obtained based on its sub-level indicators by conducting a principal component analysis. That is, after sub-indicators are indexed and standardized, and a weighted value is obtained as the aggregate indicator, which is then indexed and standardized.

In particular, for the aspect of government management, the indicator of government efficiency, that of capacity in law enforcement, that of transparency of laws and policies, and that of government organization size are first indexed and standardized; then the government management index is constructed on the basis of the values of these sub-indicators (plus some other subjective measures) based on the technique of principal component analysis.

Other determinants of the COVID-19 spread

In our study, other important determinants of the spread and control of COVID-19 are population age structure, connection with Wuhan, and the local health system's capacity. Data on population age structure (the elderly, children, and working-age population as a percentage of total population) are from the 2015 China population mini-census. Based on an index of the size of daily population flow that proxies for the total intensity of migration out of Wuhan to other cities, provided by Baidu Migration, we construct a variable by calculating the average of the migration index over 14 days before the lockdown of Wuhan. We also consider the share of Wuhan-origin residents in the city, using data from the census. Health system capacity is proxied by the total number of hospital beds in the city and the total number of hospital employees, based on data from the 2019 China City Statistical Yearbook.

Extended Data Table 1 presents the definitions and summary statistics of the above-mentioned variables.

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Subgroup Analysis

We conduct a series of subgroup analyses to further examine the role of government management capacity in the containment of the disease.

First, we divide the sample into 302 non-provincial capital cities and 30 provincial capital cities. These two groups of cities may be quite different in terms of both political and economic considerations. Extended Data Figure 3 displays the estimated coefficients on the government management index from regressions of the number of new cases (in panel A) and new recoveries (in panel B) in a week for the two subgroups of cities. As before, orange vertical bars are 90 percent confidence intervals. From the first columns, we observe that, in non-provincial capital cities, the local government has an important role in the control of COVID-19, yielding a graphical pattern that is very similar to the main results (the last columns of Figure 2 in the main text). In comparison, in provincial capital cities, the role of the local government is less obvious, although the pattern is broadly consistent. These cities typically serve as provincial centers; therefore, they receive more attention from the central government. This may explain the less obvious role of the local government.

Second, we divide the sample into 86 cities in eastern coastal provinces and 246 cities in inland provinces, based on the division of the National Bureau of Statistics. These two subgroups of cities are different mainly in terms of economic development levels. Extended Data Figure 4 displays the estimated coefficients on the government management index for the two subgroups of cities. We observe that government effectiveness appears to be negatively associated with the number of new cases and positively associated with the number of new recoveries in both eastern coastal provinces and inland provinces, and the effect is statistically significant for new recoveries in eastern coastal provinces (the bottom left panel). Yet, the effect is less precisely estimated based on these two subgroups of cities, which may be due to the reduction in the sample size.

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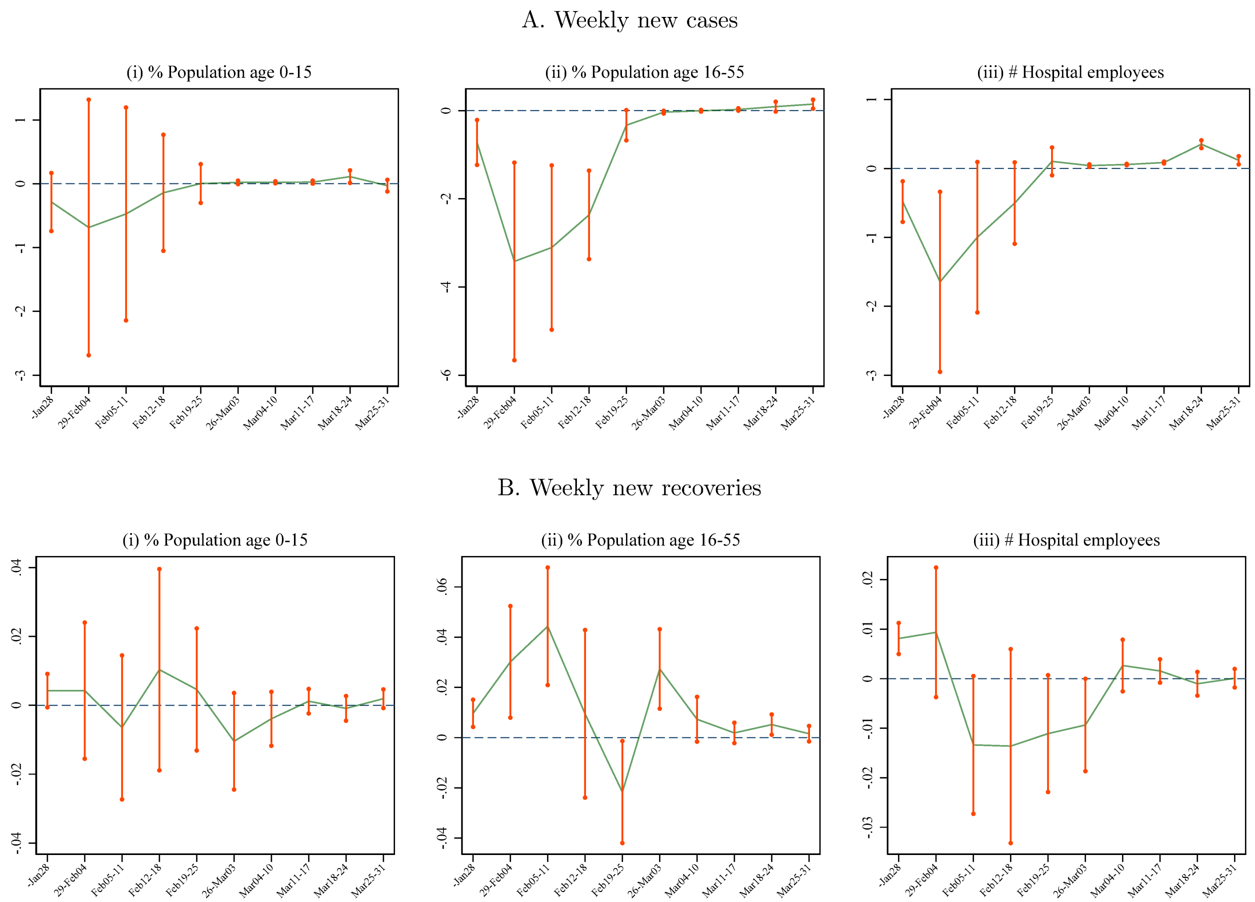
Third, we divide the sample into 320 cities outside Hubei province and 12 cities in Hubei province. Extended Data Figure 5 displays the estimated coefficients on the government management index for the two subgroups. We observe that for cities outside Hubei province, government effectiveness is negatively associated with the number of new cases and positively associated with the number of new recoveries (although the effect is not statistically significant for new recoveries); while for cities in Hubei province, the local government plays a much smaller role. The situation for cities in Hubei province is very different because they are closer to the epicenter, which had implemented more restrictive disease regulation and control measures and also received help from across the country.

Fourth, we divide the sample into 263 cities in non-Hubei-bordering provinces and 69 cities in Hubei-bordering provinces. Extended Data Figure 6 displays the estimated coefficients on the government management index for the two subgroups. From the first columns of the figure, we observe that in non-Hubei-bordering provinces, the role of the local government in the control of COVID-19 has the same graphical pattern as the main results; some loss of precision in the estimations can be attributed to the smaller sample sizes. But in Hubei-bordering provinces, the pattern of the effects appears to be mixed for both new cases and new recoveries. The cities near the epicenter of the outbreak are highly likely to be the destination city of the patient-reallocation strategy. Specifically, better government functioning in these cities increases the probability of receiving patients from other cities and, therefore, increases the probability of local coronavirus transmission and a shortage of local healthcare resources.

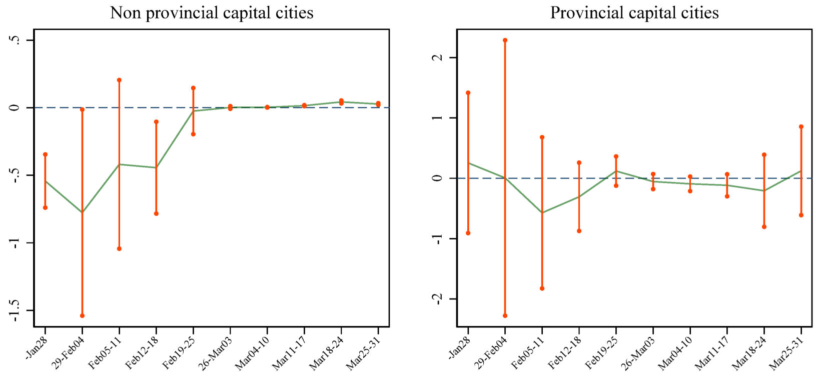
In summary, the subgroup analyses show that, with some heterogeneity and a few exceptions, higher management capacities of the local government tend to reduce newly infectious cases and to increase new recoveries.

Extended Data Figure 1. Coronavirus cases and recoveries: Key determinants (using per capita variables). Each panel displays estimated coefficients from the regressions of weekly number of new cases and recoveries normalized by population size within a city on four key determinants; 90 percent confidence intervals are shown as orange vertical bars. All regressions control for percentage of population age 65 and above, the share of Wuhan-origin residents (or an index of population flow from Wuhan), employment rate, percentage of population with a college degree, and an indicator variable for municipality. In panel B, regressions additionally control for the number of closed cases normalized by population size.

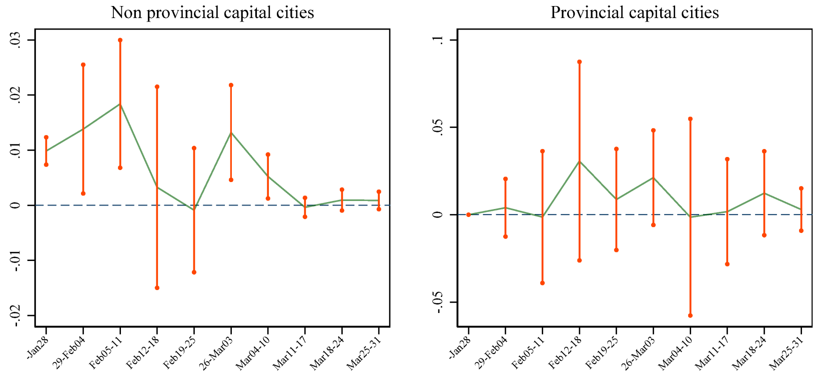


Extended Data Figure 2. Coronavirus cases and recoveries: Other factors. Each panel displays estimated coefficients from the regressions of weekly number of new cases and recoveries within a city on three factors; 90 percent confidence intervals are shown as orange vertical bars. All regressions control for population age structure, the share of Wuhan-origin residents, total population, employment rate, percentage of population with a college degree, and an indicator variable for municipality. In panel B, regressions additionally control for the number of closed cases.

A. Weekly new cases

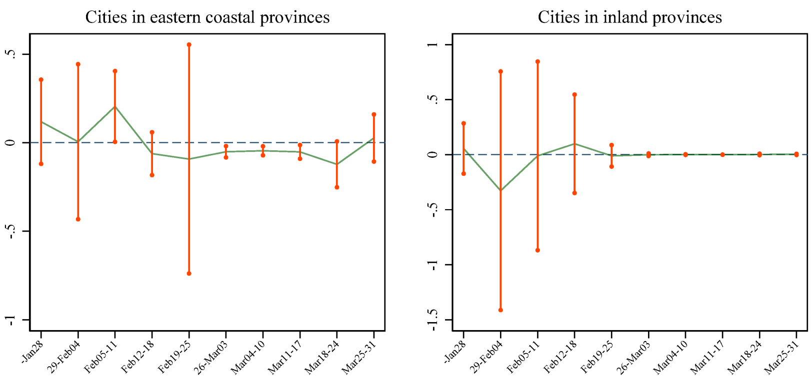


B. Weekly new recoveries

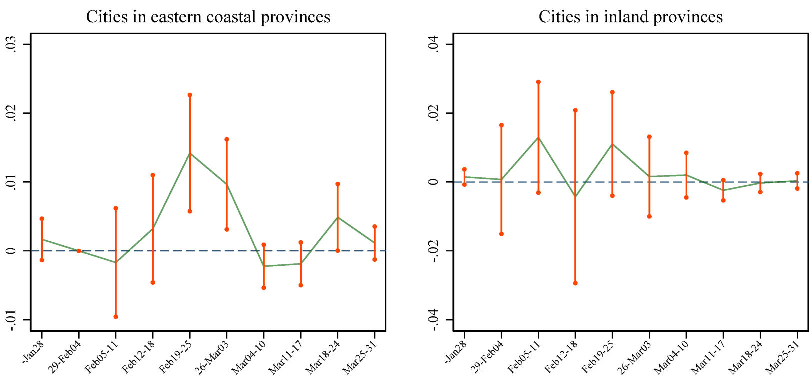


Extended Data Figure 3. Coronavirus cases and recoveries: The role of government management for non-provincial capital cities and provincial capital cities. Each panel displays estimated coefficients from the regressions of weekly number of new cases and recoveries within a city on the government management index; 90 percent confidence intervals are shown as orange vertical bars. All regressions control for percentage of population age 65 and above, the share of Wuhan-origin residents (or an index of population flow from Wuhan), total population, employment rate, percentage of population with a college degree, and an indicator variable for municipality. In panel B, regressions additionally control for the number of closed cases.

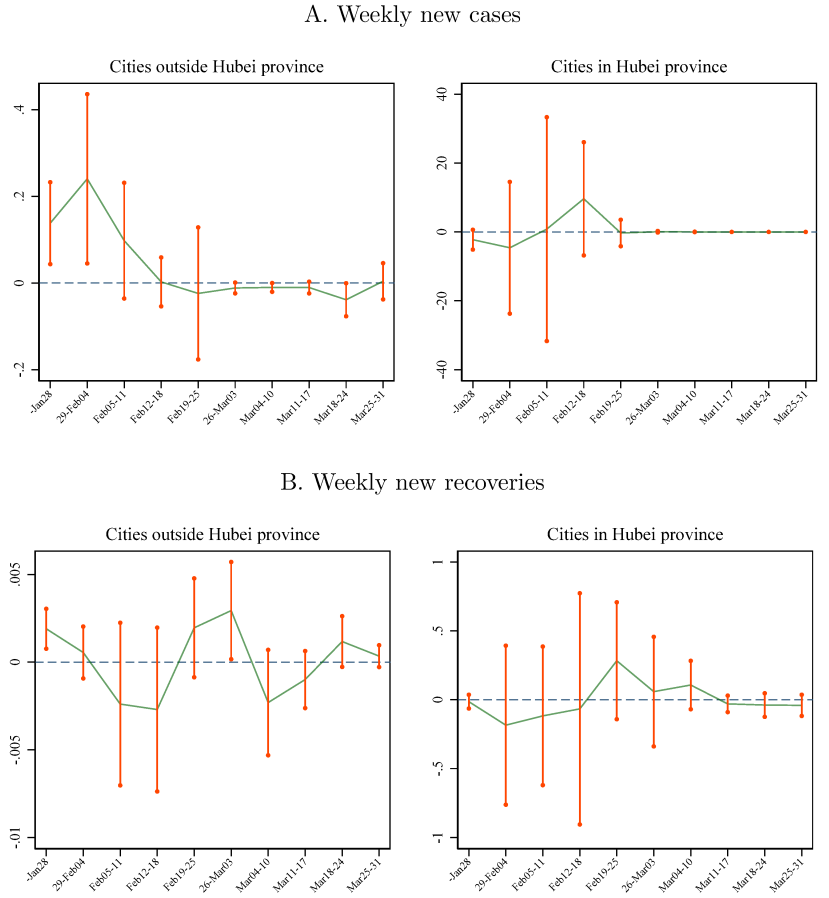
A. Weekly new cases



B. Weekly new recoveries

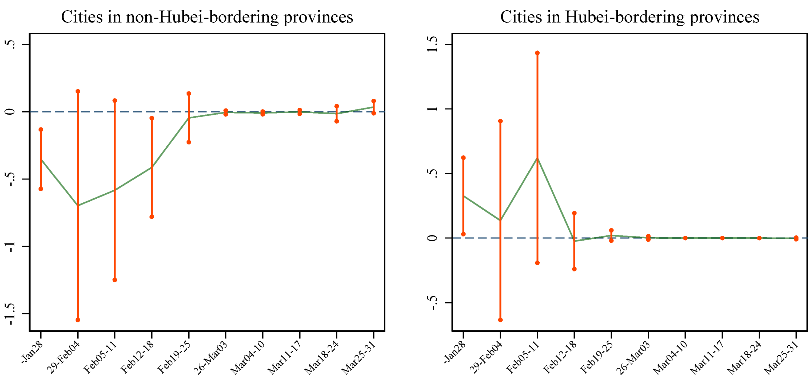


Extended Data Figure 4. Coronavirus cases and recoveries: The role of government management for cities in eastern coastal provinces and cities in inland provinces. Each panel displays estimated coefficients from the regressions of weekly number of new cases and recoveries within a city on the government management index; 90 percent confidence intervals are shown as orange vertical bars. All regressions control for percentage of population age 65 and above, the share of Wuhan-origin residents (or an index of population flow from Wuhan), total population, employment rate, percentage of population with a college degree, and an indicator variable for municipality. In panel B, regressions additionally control for the number of closed cases.

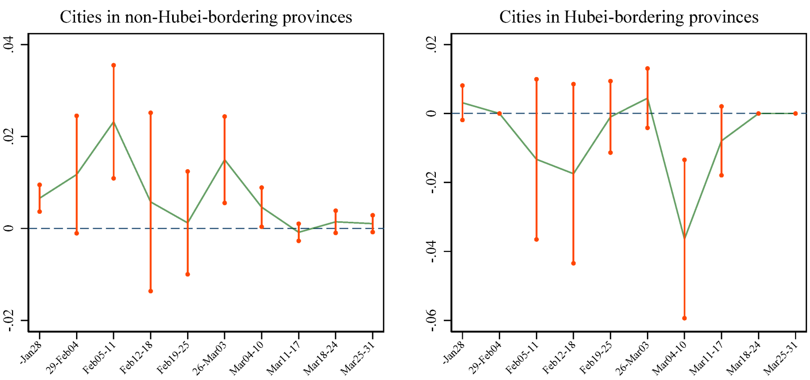


Extended Data Figure 5. Coronavirus cases and recoveries: The role of government management for cities in cities outside Hubei province and cities in Hubei province. Each panel displays estimated coefficients from the regressions of weekly number of new cases and recoveries within a city on the government management index; 90 percent confidence intervals are shown as orange vertical bars. All regressions control for percentage of population age 65 and above, the share of Wuhan-origin residents (or an index of population flow from Wuhan), total population, employment rate, percentage of population with a college degree, and an indicator variable for municipality. In panel B, regressions additionally control for the number of closed cases.

A. Weekly new cases



B. Weekly new recoveries



Extended Data Figure 6. Coronavirus cases and recoveries: The role of government management for cities in non-Hubei-bordering provinces and cities in Hubei-bordering provinces. Each panel displays estimated coefficients from the regressions of weekly number of new cases and recoveries within a city on the government management index; 90 percent confidence intervals are shown as orange vertical bars. All regressions control for percentage of population age 65 and above, the share of Wuhan-origin residents (or an index of population flow from Wuhan), total population, employment rate, percentage of population with a college degree, and an indicator variable for municipality. In panel B, regressions additionally control for the number of closed cases.

Extended Data Table 1. Definitions and summary statistics of main variables. Data on population age structure are from the 2015 China population mini-census. Data on the index of population flow are from Baidu Migration. Data on indicators of government management capabilities are from the 2019 Global Urban Competitiveness Yearbook. Data on the number of hospital beds and employees are from the 2019 China City Statistical Yearbook.

Variable name	Definition	Mean (SD)	Min	Max
A: Demographic factors				
% Population age 65 & above	Population age 65 and above as a percentage of total population	10.46 (2.551)	3.401	20.57
% Population age 0–15	Population age 0–15 as a percentage of total population	18.68 (4.876)	7.907	32.73
% Population age 16–55	Population age 16–55 as a percentage of total population	60.41 (4.008)	51.53	80.86
Population flow index, from Wuhan	Average of daily population flow from Wuhan over 14 days before lockdown	26.65 (111.5)	0	1,251
B: Government management capabilities				
Government management index	Overall management level and public policy environment	34.81 (11.84)	10	95.20
Government efficiency	Administrative procedures and time lags in government's services	28.24 (12.17)	10	100
Capacity for law enforcement	Government's ability to enforce the rule of law	33.50 (13.88)	10	100
Transparency of laws and policies	How well laws and policies stipulated by government are known to citizens	32.32 (13.16)	10	100
Government organization size	Employees in government agencies and organizations as a percentage of total population	56.06 (20.88)	10	100
C: Health system capacity				
# Hospital beds	Number of beds in all hospitals in the city, thousand	12.18 (19.21)	0	190.1
# Hospital employees	Number of employees in all hospitals in the city, thousand	2.697 (8.980)	0	100.9
Observations				332

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Supplementary File 2

This document contains Tables S1-1 to S1-10, Tables S2-1 to S2-10, and Tables S3-1 to S3-10.

Table S1-1. Coronavirus cases and recoveries for the week ending Jan. 28: Key determinants. Other control variables include the share of Wuhan-origin residents (or an index of population flow from Wuhan), total population, employment rate, percentage of population with a college degree, and an indicator variable for municipality. For weekly new recoveries, regressions additionally control for the number of closed cases. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	1.653***	0.528**	1.951***	1.604***	-0.018***	-0.014***	-0.023***	-0.017***
	(0.475)	(0.234)	(0.478)	(0.474)	(0.005)	(0.004)	(0.005)	(0.005)
Pop. flow index, Wuhan		0.245***				-0.001***		
		(0.005)				(0.000)		
Gov. management index			-0.480***				0.007***	
			(0.151)				(0.002)	
# Hospital beds				-0.226*				0.004***
				(0.122)				(0.001)
Observations	332	332	332	332	332	332	332	332
R-squared	0.527	0.884	0.542	0.532	0.714	0.778	0.732	0.724
Dependent variable mean	11.596	11.596	11.596	11.596	0.066	0.066	0.066	0.066
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table S1-2. Coronavirus cases and recoveries for the week ending Feb. 4: Key factors. See notes to Table S1-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	6.507***	2.108**	7.853***	6.242***	-0.036*	-0.025	-0.046**	-0.034
	(2.100)	(0.930)	(2.110)	(2.090)	(0.021)	(0.019)	(0.022)	(0.021)
Pop. flow index, Wuhan		1.023***				-0.007***		
		(0.021)				(0.001)		
Gov. management index			-2.171***				0.014**	
			(0.667)				(0.007)	
# Hospital beds				-1.204**				0.013**
				(0.539)				(0.005)
Observations	332	332	332	332	332	332	332	332
R-squared	0.409	0.883	0.428	0.418	0.940	0.951	0.941	0.942
Dependent variable mean	33.925	33.925	33.925	33.925	1.380	1.380	1.380	1.380
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table S1-3. Coronavirus cases and recoveries for the week ending Feb. 11: Key factors. See notes to Table S1-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	5.375***	1.838**	6.460***	5.188***	-0.044**	-0.053***	-0.060***	-0.042*
	(1.749)	(0.739)	(1.760)	(1.745)	(0.022)	(0.018)	(0.023)	(0.022)
Pop. flow index, Wuhan		0.842***				-0.014***		
		(0.017)				(0.001)		
Gov. management index			-1.749***				0.023***	
			(0.556)				(0.007)	
# Hospital beds				-0.849*				0.013**
				(0.450)				(0.006)
Observations	332	332	332	332	332	332	332	332
R-squared	0.377	0.888	0.396	0.384	0.998	0.999	0.998	0.998
Dependent variable mean	25.774	25.774	25.774	25.774	8.057	8.057	8.057	8.057
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table S1-4. Coronavirus cases and recoveries for the week ending Feb. 18: Key factors. See notes to Table S1-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	3.622***	1.272***	4.390***	3.515***	-0.015	-0.050*	-0.019	-0.015
	(0.946)	(0.468)	(0.941)	(0.943)	(0.032)	(0.028)	(0.032)	(0.032)
Pop. flow index, Wuhan		0.501***				-0.015***		
		(0.011)				(0.002)		
Gov. management index			-1.240***				0.005	
			(0.297)				(0.010)	
# Hospital beds				-0.484**				-0.002
				(0.243)				(0.008)
Observations	332	332	332	332	332	332	332	332
R-squared	0.487	0.873	0.513	0.494	0.999	1.000	0.999	0.999
Dependent variable mean	12.804	12.804	12.804	12.804	17.428	17.428	17.428	17.428
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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Table S1-5. Coronavirus cases and recoveries for the week ending Feb. 25: Key factors. See notes to Table S1-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	0.450	0.149	0.586*	0.435	0.026	-0.009	0.026	0.026
	(0.322)	(0.276)	(0.327)	(0.323)	(0.019)	(0.019)	(0.020)	(0.019)
Pop. flow index, Wuhan		0.080***				-0.006***		
		(0.006)				(0.001)		
Gov. management index			-0.219**				0.001	
			(0.103)				(0.006)	
# Hospital beds				-0.068				-0.002
				(0.083)				(0.005)
Observations	332	332	332	332	332	332	332	332
R-squared	0.115	0.344	0.127	0.117	1.000	1.000	1.000	1.000
Dependent variable mean	2.428	2.428	2.428	2.428	23.786	23.786	23.786	23.786
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table S1-6. Coronavirus cases and recoveries for the week ending Mar. 3: Key factors. See notes to Table S1-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	0.022	-0.009	0.036	0.026	-0.018	-0.019	-0.028*	-0.019
	(0.030)	(0.025)	(0.030)	(0.030)	(0.015)	(0.012)	(0.015)	(0.015)
Pop. flow index, Wuhan		0.008***				-0.011***		
		(0.001)				(0.001)		
Gov. management index			-0.022**				0.014***	
			(0.010)				(0.005)	
# Hospital beds				0.018**				-0.002
				(0.008)				(0.004)
Observations	332	332	332	332	332	332	332	332
R-squared	0.263	0.488	0.275	0.275	1.000	1.000	1.000	1.000
Dependent variable mean	0.292	0.292	0.292	0.292	19.584	19.584	19.584	19.584
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table S1-7. Coronavirus cases and recoveries for the week ending Mar. 10: Key factors. See notes to Table S1-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	-0.022	-0.025	-0.018	-0.015	-0.001	-0.001	-0.004	-0.001
	(0.017)	(0.017)	(0.017)	(0.016)	(0.008)	(0.008)	(0.009)	(0.008)
Pop. flow index, Wuhan		0.001				-0.002***		
		(0.000)				(0.000)		
Gov. management index			-0.006				0.004	
			(0.006)				(0.003)	
# Hospital beds				0.032***				-0.002
				(0.004)				(0.002)
Observations	332	332	332	332	332	332	332	332
R-squared	0.478	0.480	0.480	0.562	1.000	1.000	1.000	1.000
Dependent variable mean	0.099	0.099	0.099	0.099	9.883	9.883	9.883	9.883
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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Table S1-8. Coronavirus cases and recoveries for the week ending Mar. 17: Key factors. See notes to Table S1-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	-0.057**	-0.063**	-0.059**	-0.045**	-0.003	-0.001	-0.002	-0.003
	(0.025)	(0.025)	(0.026)	(0.023)	(0.004)	(0.004)	(0.004)	(0.004)
Pop. flow index, Wuhan		0.001				0.000**		
		(0.001)				(0.000)		
Gov. management index			0.004				-0.001	
			(0.008)				(0.001)	
# Hospital beds				0.055***				0.000
				(0.006)				(0.001)
Observations	332	332	332	332	332	332	332	332
R-squared	0.530	0.527	0.530	0.631	1.000	1.000	1.000	1.000
Dependent variable mean	0.175	0.175	0.175	0.175	3.322	3.322	3.322	3.322
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table S1-9. Coronavirus cases and recoveries for the week ending Mar. 24: Key factors. See notes to Table S1-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	-0.220**	-0.241**	-0.220**	-0.167*	-0.005	-0.003	-0.006	-0.005
	(0.104)	(0.104)	(0.106)	(0.091)	(0.004)	(0.004)	(0.004)	(0.004)
Pop. flow index, Wuhan		0.003				-0.000***		
		(0.002)				(0.000)		
Gov. management index			0.001				0.001	
			(0.034)				(0.001)	
# Hospital beds				0.240***				-0.000
				(0.023)				(0.001)
Observations	332	332	332	332	332	332	332	332
R-squared	0.578	0.577	0.578	0.680	0.999	0.999	0.999	0.999
Dependent variable mean	0.768	0.768	0.768	0.768	1.018	1.018	1.018	1.018
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table S1-10. Coronavirus cases and recoveries for the week ending Mar. 31: Key factors. See notes to Table S1-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	-0.126	-0.157	-0.152	-0.093	-0.006**	-0.005*	-0.006**	-0.006**
	(0.097)	(0.097)	(0.098)	(0.091)	(0.003)	(0.003)	(0.003)	(0.003)
Pop. flow index, Wuhan		0.003				-0.000**		
		(0.002)				(0.000)		
Gov. management index			0.042				0.001	
			(0.031)				(0.001)	
# Hospital beds				0.152***				0.001
				(0.024)				(0.001)
Observations	332	332	332	332	332	332	332	332
R-squared	0.440	0.433	0.443	0.504	0.994	0.994	0.994	0.994
Dependent variable mean	0.633	0.633	0.633	0.633	0.250	0.250	0.250	0.250
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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Table S2-1. Coronavirus cases and recoveries for the week ending Jan. 28: Other factors. Other control variables include the share of Wuhan-origin residents, total population, employment rate, percentage of population with a college degree, and an indicator variable for municipality. For weekly new recoveries, regressions additionally control for the number of closed cases. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases			Weekly new recoveries		
	(1)	(2)	(3)	(4)	(5)	(6)
% Pop. age 65 & above			1.691***			-0.019***
			(0.471)			(0.005)
% Population age 0–15	-0.286			0.004		
	(0.276)			(0.003)		
% Population age 16–55		-0.721**			0.010***	
		(0.309)			(0.003)	
# Hospital employees			-0.479***			0.008***
			(0.179)			(0.002)
Observations	332	332	332	332	332	332
R-squared	0.511	0.518	0.538	0.705	0.710	0.729
Dependent variable mean	11.596	11.596	11.596	0.066	0.066	0.066
Other controls	Yes	Yes	Yes	Yes	Yes	Yes

Table S2-2. Coronavirus cases and recoveries for the week ending Feb. 4: Other factors. See notes to Table S2-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases			Weekly new recoveries		
	(1)	(2)	(3)	(4)	(5)	(6)
% Pop. age 65 & above			6.637***			-0.037*
			(2.090)			(0.021)
% Population age 0–15	-0.685			0.004		
	(1.214)			(0.012)		
% Population age 16–55		-3.419**			0.030**	
		(1.359)			(0.013)	
# Hospital employees			-1.645**			0.009
			(0.792)			(0.008)
Observations	332	332	332	332	332	332
R-squared	0.393	0.404	0.417	0.940	0.941	0.941
Dependent variable mean	33.925	33.925	33.925	1.380	1.380	1.380
Other controls	Yes	Yes	Yes	Yes	Yes	Yes

Table S2-3. Coronavirus cases and recoveries for the week ending Feb. 11: Other factors. See notes to Table S2-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases			Weekly new recoveries		
	(1)	(2)	(3)	(4)	(5)	(6)
% Pop. age 65 & above			5.454***			-0.042*
			(1.747)			(0.022)
% Population age 0–15	-0.473			-0.006		
	(1.011)			(0.013)		
% Population age 16–55		-3.104***			0.044***	
		(1.130)			(0.014)	
# Hospital employees			-0.997			-0.013
			(0.662)			(0.008)
Observations	332	332	332	332	332	332
R-squared	0.359	0.374	0.381	0.998	0.998	0.998
Dependent variable mean	25.774	25.774	25.774	8.057	8.057	8.057
Other controls	Yes	Yes	Yes	Yes	Yes	Yes

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Table S2-4. Coronavirus cases and recoveries for the week ending Feb. 18: Other factors. See notes to Table S2-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases			Weekly new recoveries		
	(1)	(2)	(3)	(4)	(5)	(6)
% Pop. age 65 & above			3.661***			-0.013
			(0.945)			(0.032)
% Population age 0–15	-0.141			0.010		
	(0.551)			(0.018)		
% Population age 16–55		-2.364***			0.009	
		(0.609)			(0.020)	
# Hospital employees			-0.501			-0.014
			(0.358)			(0.012)
Observations	332	332	332	332	332	332
R-squared	0.464	0.488	0.490	0.999	0.999	0.999
Dependent variable mean	12.804	12.804	12.804	17.428	17.428	17.428
Other controls	Yes	Yes	Yes	Yes	Yes	Yes

Table S2-5. Coronavirus cases and recoveries for the week ending Feb. 25: Other factors. See notes to Table S2-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases			Weekly new recoveries		
	(1)	(2)	(3)	(4)	(5)	(6)
% Pop. age 65 & above			0.442			0.028
			(0.323)			(0.019)
% Population age 0–15	0.004			0.005		
	(0.184)			(0.011)		
% Population age 16–55		-0.330			-0.022*	
		(0.207)			(0.012)	
# Hospital employees			0.104			-0.011
			(0.122)			(0.007)
Observations	332	332	332	332	332	332
R-squared	0.110	0.117	0.117	1.000	1.000	1.000
Dependent variable mean	2.428	2.428	2.428	23.786	23.786	23.786
Other controls	Yes	Yes	Yes	Yes	Yes	Yes

Table S2-6. Coronavirus cases and recoveries for the week ending Mar. 3: Other factors. See notes to Table S2-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases			Weekly new recoveries		
	(1)	(2)	(3)	(4)	(5)	(6)
% Pop. age 65 & above			0.019			-0.017
			(0.029)			(0.015)
% Population age 0–15	0.022			-0.010		
	(0.017)			(0.009)		
% Population age 16–55		-0.033*			0.027***	
		(0.019)			(0.010)	
# Hospital employees			0.042***			-0.009*
			(0.011)			(0.006)
Observations	332	332	332	332	332	332
R-squared	0.265	0.268	0.295	1.000	1.000	1.000
Dependent variable mean	0.292	0.292	0.292	19.584	19.584	19.584
Other controls	Yes	Yes	Yes	Yes	Yes	Yes

Table S2-7. Coronavirus cases and recoveries for the week ending Mar. 10: Other factors. See notes to Table S2-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases			Weekly new recoveries		
	(1)	(2)	(3)	(4)	(5)	(6)
% Pop. age 65 & above			-0.027*			-0.001
			(0.015)			(0.008)
% Population age 0–15	0.024**			-0.004		
	(0.010)			(0.005)		
% Population age 16–55		-0.002			0.007	
		(0.011)			(0.005)	
# Hospital employees			0.058***			0.003
			(0.006)			(0.003)
Observations	332	332	332	332	332	332
R-squared	0.485	0.475	0.607	1.000	1.000	1.000
Dependent variable mean	0.099	0.099	0.099	9.883	9.883	9.883
Other controls	Yes	Yes	Yes	Yes	Yes	Yes

Table S2-8. Coronavirus cases and recoveries for the week ending Mar. 17: Other factors. See notes to Table S2-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases			Weekly new recoveries		
	(1)	(2)	(3)	(4)	(5)	(6)
% Pop. age 65 & above			-0.064***			-0.003
			(0.022)			(0.004)
% Population age 0–15	0.026*			0.001		
	(0.015)			(0.002)		
% Population age 16–55		0.028*			0.002	
		(0.016)			(0.002)	
# Hospital employees			0.087***			0.002
			(0.008)			(0.001)
Observations	332	332	332	332	332	332
R-squared	0.527	0.527	0.648	1.000	1.000	1.000
Dependent variable mean	0.175	0.175	0.175	3.322	3.322	3.322
Other controls	Yes	Yes	Yes	Yes	Yes	Yes

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Table S2-9. Coronavirus cases and recoveries for the week ending Mar. 24: Other factors. See notes to Table S2-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases			Weekly new recoveries		
	(1)	(2)	(3)	(4)	(5)	(6)
% Pop. age 65 & above			-0.248***			-0.005
			(0.091)			(0.004)
% Population age 0–15	0.112*			-0.001		
	(0.060)			(0.002)		
% Population age 16–55		0.092			0.005**	
		(0.067)			(0.002)	
# Hospital employees			0.353***			-0.001
			(0.034)			(0.001)
Observations	332	332	332	332	332	332
R-squared	0.576	0.574	0.681	0.999	0.999	0.999
Dependent variable mean	0.768	0.768	0.768	1.018	1.018	1.018
Other controls	Yes	Yes	Yes	Yes	Yes	Yes

Table S2-10. Coronavirus cases and recoveries for the week ending Mar. 31: Other factors. See notes to Table S2-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases			Weekly new recoveries		
	(1)	(2)	(3)	(4)	(5)	(6)
% Pop. age 65 & above			-0.136			-0.006**
			(0.095)			(0.003)
% Population age 0–15	-0.029			0.002		
	(0.055)			(0.002)		
% Population age 16–55		0.148**			0.002	
		(0.062)			(0.002)	
# Hospital employees			0.120***			0.000
			(0.036)			(0.001)
Observations	332	332	332	332	332	332
R-squared	0.438	0.447	0.459	0.994	0.994	0.994
Dependent variable mean	0.633	0.633	0.633	0.250	0.250	0.250
Other controls	Yes	Yes	Yes	Yes	Yes	Yes

Table S3-1. Coronavirus cases and recoveries for the week ending Jan. 28: The role of government management. Other control variables include the share of Wuhan-origin residents, total population, employment rate, percentage of population with a college degree, and an indicator variable for municipality. For weekly new recoveries, regressions additionally control for the number of closed cases. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	1.874***	2.109***	1.969***	1.652***	-0.022***	-0.025***	-0.023***	-0.017***
	(0.473)	(0.485)	(0.483)	(0.481)	(0.005)	(0.005)	(0.005)	(0.005)
Gov. efficiency	-0.521***				0.010***			
	(0.158)				(0.002)			
Cap. for law enforcement		-0.468***				0.007***		
		(0.133)				(0.001)		
Trans. of laws/policies			-0.410***				0.006***	
			(0.143)				(0.002)	
Gov. organization size				-0.001				0.001
				(0.060)				(0.001)
Observations	332	332	332	332	332	332	332	332
R-squared	0.543	0.545	0.539	0.527	0.744	0.733	0.729	0.714
Dependent variable mean	11.596	11.596	11.596	11.596	0.066	0.066	0.066	0.066
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table S3-2. Coronavirus cases and recoveries for the week ending Feb. 4: The role of government management. See notes to Table S3-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	7.433***	8.472***	7.883***	6.358***	-0.043**	-0.051**	-0.046**	-0.033
	(2.093)	(2.144)	(2.133)	(2.122)	(0.021)	(0.022)	(0.022)	(0.021)
Gov. efficiency	-2.186***				0.014*			
	(0.698)				(0.007)			
Cap. for law enforcement		-2.017***				0.014**		
		(0.588)				(0.006)		
Trans. of laws/policies			-1.791***				0.011*	
			(0.631)				(0.006)	
Gov. organization size				-0.137				0.003
				(0.266)				(0.003)
Observations	332	332	332	332	332	332	332	332
R-squared	0.427	0.430	0.424	0.410	0.941	0.941	0.941	0.941
Dependent variable mean	33.925	33.925	33.925	33.925	1.380	1.380	1.380	1.380
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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Table S3-3. Coronavirus cases and recoveries for the week ending Feb. 11: The role of government management. See notes to Table S3-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	6.118***	7.031***	6.415***	5.182***	-0.057**	-0.068***	-0.065***	-0.040*
	(1.745)	(1.785)	(1.781)	(1.767)	(0.022)	(0.023)	(0.023)	(0.023)
Gov. efficiency	-1.753***				0.026***			
	(0.582)				(0.007)			
Cap. for law enforcement		-1.700***				0.022***		
		(0.490)				(0.006)		
Trans. of laws/policies			-1.354**				0.024***	
			(0.527)				(0.007)	
Gov. organization size				-0.178				0.004
				(0.222)				(0.003)
Observations	332	332	332	332	332	332	332	332
R-squared	0.394	0.399	0.390	0.378	0.998	0.998	0.998	0.998
Dependent variable mean	25.774	25.774	25.774	25.774	8.057	8.057	8.057	8.057
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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Table S3-4. Coronavirus cases and recoveries for the week ending Feb. 18: The role of government management. See notes to Table S3-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	4.179***	4.727***	4.452***	3.521***	-0.018	-0.026	-0.016	-0.013
	(0.931)	(0.956)	(0.951)	(0.955)	(0.032)	(0.033)	(0.033)	(0.032)
Gov. efficiency	-1.316***				0.006			
	(0.311)				(0.011)			
Cap. for law enforcement		-1.134***				0.011		
		(0.262)				(0.009)		
Trans. of laws/policies			-1.081***				0.001	
			(0.281)				(0.010)	
Gov. organization size				-0.093				0.002
				(0.120)				(0.004)
Observations	332	332	332	332	332	332	332	332
R-squared	0.514	0.515	0.510	0.488	0.999	0.999	0.999	0.999
Dependent variable mean	12.804	12.804	12.804	12.804	17.428	17.428	17.428	17.428
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table S3-5. Coronavirus cases and recoveries for the week ending Feb. 25: The role of government management. See notes to Table S3-1. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	0.558*	0.696**	0.591*	0.444	0.028	0.024	0.026	0.027
	(0.323)	(0.331)	(0.330)	(0.326)	(0.020)	(0.020)	(0.020)	(0.019)
Gov. efficiency	-0.255**				-0.003			
	(0.108)				(0.006)			
Cap. for law enforcement		-0.252***				0.002		
		(0.091)				(0.005)		
Trans. of laws/policies			-0.182*				0.001	
			(0.097)				(0.006)	
Gov. organization size				-0.006				0.001
				(0.041)				(0.002)
Observations	332	332	332	332	332	332	332	332
R-squared	0.130	0.136	0.125	0.115	1.000	1.000	1.000	1.000
Dependent variable mean	2.428	2.428	2.428	2.428	23.786	23.786	23.786	23.786
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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Table S3-6. Coronavirus cases and recoveries for the week ending Mar. 3: The role of government management. See notes to Table S3-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	0.031	0.044	0.035	0.019	-0.026*	-0.029*	-0.029*	-0.018
	(0.030)	(0.031)	(0.031)	(0.030)	(0.015)	(0.016)	(0.015)	(0.015)
Gov. efficiency	-0.021**				0.017***			
	(0.010)				(0.005)			
Cap. for law enforcement		-0.023***				0.010**		
		(0.008)				(0.004)		
Trans. of laws/policies			-0.017*				0.013***	
			(0.009)				(0.005)	
Gov. organization size				-0.003				0.001
				(0.004)				(0.002)
Observations	332	332	332	332	332	332	332	332
R-squared	0.272	0.279	0.271	0.264	1.000	1.000	1.000	1.000
Dependent variable mean	0.292	0.292	0.292	0.292	19.584	19.584	19.584	19.584
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table S3-7. Coronavirus cases and recoveries for the week ending Mar. 10: The role of government management. See notes to Table S3-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	-0.020	-0.018	-0.017	-0.021	-0.003	-0.003	-0.003	-0.000
	(0.017)	(0.018)	(0.018)	(0.017)	(0.009)	(0.009)	(0.009)	(0.009)
Gov. efficiency	-0.004				0.004			
	(0.006)				(0.003)			
Cap. for law enforcement		-0.005				0.002		
		(0.005)				(0.002)		
Trans. of laws/policies			-0.006				0.003	
			(0.005)				(0.003)	
Gov. organization size				0.001				0.000
				(0.002)				(0.001)
Observations	332	332	332	332	332	332	332	332
R-squared	0.479	0.479	0.480	0.478	1.000	1.000	1.000	1.000
Dependent variable mean	0.099	0.099	0.099	0.099	9.883	9.883	9.883	9.883
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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Table S3-8. Coronavirus cases and recoveries for the week ending Mar. 17: The role of government management. See notes to Table S3-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	-0.063**	-0.059**	-0.059**	-0.055**	-0.002	-0.001	-0.002	-0.003
	(0.026)	(0.026)	(0.026)	(0.026)	(0.004)	(0.004)	(0.004)	(0.004)
Gov. efficiency	0.015*				-0.001			
	(0.009)				(0.001)			
Cap. for law enforcement		0.003				-0.001		
		(0.007)				(0.001)		
Trans. of laws/policies			0.003				-0.001	
			(0.008)				(0.001)	
Gov. organization size				0.002				-0.000
				(0.003)				(0.000)
Observations	332	332	332	332	332	332	332	332
R-squared	0.535	0.530	0.530	0.530	1.000	1.000	1.000	1.000
Dependent variable mean	0.175	0.175	0.175	0.175	3.322	3.322	3.322	3.322
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table S3-9. Coronavirus case and recoveries for the week ending Mar. 24: The role of government management. See notes to Table S3-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	-0.238**	-0.217**	-0.216**	-0.210**	-0.005	-0.006	-0.006	-0.005
	(0.105)	(0.108)	(0.107)	(0.105)	(0.004)	(0.004)	(0.004)	(0.004)
Gov. efficiency	0.042				-0.000			
	(0.035)				(0.001)			
Cap. for law enforcement		-0.003				0.001		
		(0.030)				(0.001)		
Trans. of laws/policies			-0.005				0.001	
			(0.032)				(0.001)	
Gov. organization size				0.009				0.000
				(0.013)				(0.000)
Observations	332	332	332	332	332	332	332	332
R-squared	0.579	0.578	0.578	0.578	0.999	0.999	0.999	0.999
Dependent variable mean	0.768	0.768	0.768	0.768	1.018	1.018	1.018	1.018
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table S3-10. Coronavirus cases and recoveries for the week ending Mar. 31: The role of government management. See notes to Table S3-1. *** p<0.01, ** p<0.05, * p<0.1.

Dependent variable	Weekly new cases				Weekly new recoveries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Pop. age 65 & above	-0.171*	-0.154	-0.158	-0.123	-0.006**	-0.007**	-0.006**	-0.006**
	(0.096)	(0.100)	(0.099)	(0.098)	(0.003)	(0.003)	(0.003)	(0.003)
Gov. efficiency	0.106***				0.000			
	(0.032)				(0.001)			
Cap. for law enforcement		0.028				0.001		
		(0.028)				(0.001)		
Trans. of laws/policies			0.041				0.000	
			(0.029)				(0.001)	
Gov. organization size				0.003				0.000
				(0.012)				(0.000)
Observations	332	332	332	332	332	332	332	332
R-squared	0.459	0.442	0.444	0.441	0.994	0.994	0.994	0.994
Dependent variable mean	0.633	0.633	0.633	0.633	0.250	0.250	0.250	0.250
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes